PATENT ABSTRACTS OF JAPAN

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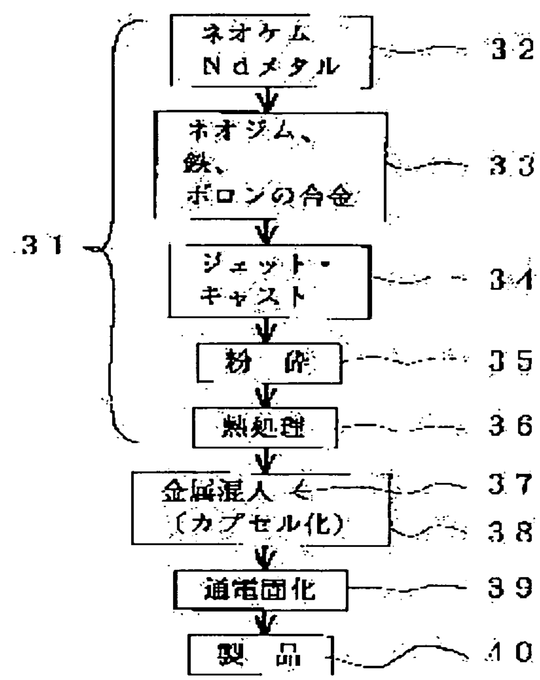
(54) MANUFACTURE OF METAL MAGNET

(57)Abstract:
PURPOSE: To provide a method of manufacturing a metal magnet which enables solidification of a quenching solidifyable magnetic powder including amorphous with a metal having a higher melting point than the crystallization temperature and ensures sufficient magnetic characteristic and applicable strength.
CONSTITUTION: Rapidly solidified magnetic particles, which may be amorphous, are mixed with metal particles having a melting point higher than the crystallization temperature of the magnetic particles. The gain boundary thereof is activated through application of electrical power for the solidification 39.



CLAIMS

[Claim(s)]
[Claim 1]A manufacturing method of a metal magnet characterized by making into a mother particle rapid solidification system magnetic powder containing AMORUFASU, making into child particles metal whose melting point is higher than crystallization temperature of this rapid solidification system magnetic powder, mixing, changing the grain boundary side into an activity state by energization, and making it solidify.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]This invention relates to the manufacturing method of the metal magnet which uses the metal in which the boiling point is higher than the crystallization temperature of this rapid solidification system magnetic powder as child particles by making into a mother particle rapid solidification system magnetic powder which is applied to the manufacturing method of a metal magnet, especially contains AMORUFASU.
[0002]
[Description of the Prior Art]Generally, the plastic magnet is accomplished by carrying out the joint solidification of the rapid solidification system magnetic powder which contains AMORUFASU using a plastic as a binder.
[0003]Specifically, the manufacturing method of the plastic magnet is accomplished, as shown in drawing 6. The alloy 2 of neodium (Nd), iron (Fe), and boron (B) is first mixed in the NEOKEMU Nd metal 1 as illustrated. Next, what carried out this mixture jet cast 3 is carried out grinding 4, and disintegration is carried out. And after performing predetermined heat treatment 5 to this, the epoxy resin 6 is mixed as a binder and it takes press 7. Then, this press-forming article is carried out curing treatment 8, and it is considered as the product 9.
[0004]However, if it is in the above-mentioned plastic magnet, the plastic is used as a binder which solidifies magnetic powder. Since it must mix not less than 15% by volume not less than 3% with weight to magnetic powder, this plastic cannot pull out performance of the above-mentioned magnetic powder 100%. To a temperature change, a plastic magnet is weak, and changes at 200 ** at the elevated-temperature side, and a crack arises at -20 ** at the low temperature side. Therefore, a plastic magnet cannot be used in a broad temperature requirement. In a mechanical strength, although there is also correlation with temperature, it does not have intensity [in addition to a specific temperature field] other than -10 ** - 150 **, for example. And it is difficult for the plastic used as a binder to recycle what it went variously and was once manufactured as a plastic magnet.
[0005]Then, the metal magnet is improved. That for which this metal magnet used the cast magnet or the sintered magnet is used abundantly. The above-mentioned cast magnet is manufactured in the casting process which is made to carry out thermofusion of the metallic component by high frequency, and is cast to a mold, and the above-mentioned sintered magnet is manufactured with the sintering process which used tin series metal as the binder.
[0006]Specifically, the manufacturing method of the above-mentioned sintered magnet is accomplished, as shown in drawing 7. These are first carried out combination 11 by a predetermined daily dose by making Nd, Fe, B, etc. into the raw material 10 as illustrated. Next, this feed ingredient is carried out dissolution 12, and it is casting 13 ** in a mold. After releasing from mold and carrying out a casting coarse-grinding 14 after solidification, it takes pulverizing 15 with a ball mill etc. And this powder is carried out shaping 16 in a magnetic field, and predetermined heat treatment 18 is performed after the sintering 17. Then, this is carried out polishing work 19 and it is considered as the product 20.
[0007]

[Problem(s) to be Solved by the Invention]by the way -- if it is in the conventional metal magnet -- a casting process and a sintering process (a binder is included) -- it needs both to be heated more than the melting point. Therefore, the temperature transformation of crystallization etc. was located in the third grade of the melting point, and the rapid solidification system magnetic powder containing AMORUFASU had the problem that what has the desired characteristic could not be manufactured, in these casting processes and a sintering process. Although the sintering process was manufactured in consideration of deterioration temperature in part, in order to have to choose the binder metal of a low melting point, there was a problem that sufficient usable intensity could not be obtained.
[0008]The purpose of this invention is in view of an aforementioned problem to provide the manufacturing method of the metal magnet which can solidify the rapid solidification system magnetic powder containing AMORUFASU using the metal whose melting point is higher than the crystallization temperature, and can obtain sufficient magnetic property and usable intensity.
[0009]
[Means for Solving the Problem]According to the manufacturing method of a metal magnet concerning this invention, rapid solidification system magnetic powder containing AMORUFASU is made into a mother particle, and metal whose melting point is higher than crystallization temperature of this rapid solidification system magnetic powder is made into child particles, it mixes, and the above-mentioned purpose is attained by changing that grain boundary side into an activity state by energization, and having made it solidify.
[0010]
[Function]According to the above-mentioned composition, the rapid solidification system magnetic powder containing AMORUFASU was used as a mother particle, and metal was used as child particles, and these were mixed. For example, it is mixable in the state of a capsule so that child particles may wrap a mother particle in setting the diameter of child particles as 1/20 from 1/10 to the diameter of a mother particle.
[0011]By using the energization solidifying method which faces the rapid solidification system magnetic powder containing AMORUFASU as the above-mentioned mother particle solidifying using the metal as the above-mentioned child particles, changes the grain boundary side into an activity state by energization, and is solidified, The rapid solidification system magnetic powder containing AMORUFASU can be solidified using the metal whose melting point is higher than the crystallization temperature.
[0012]Therefore, since the metal whose melting point is higher than the crystallization temperature of the rapid solidification system magnetic powder containing AMORUFASU can be used, sufficient magnetic property and usable intensity can be obtained.
[0013]
[Example]Hereafter, suitable 1 example of the manufacturing method of the metal magnet concerning this invention is explained in full detail based on an accompanying drawing.
[0014]Drawing 1 is an explanatory view showing the manufacturing method of the metal magnet of this example. the rapid solidification system Nd-Fe-B magnetic powder which used the single chill roll method for the amorphous magnetic material as the mother particle 31, and was manufactured was boiled and used as illustrated. Amorphous magnetic powder is also included in this rapid solidification system magnetic powder. This amorphous ****** is the meaning in which a rapid solidification system alloy contains what is amorphous with material composition since micro crystallite is metastable with quenching about that sequence regularity.
[0015]After mixing the alloy 33 of neodium (Nd), iron (Fe), and boron (B) in the NEOKEMU Nd metal 32, making grinding 35 what carried out this mixture jet cast 34 it and carrying out disintegration to it first, the above-mentioned mother particle 31 performs predetermined heat treatment 36 to this, and, specifically, is manufactured. The jet cast by this single chill roll method carries out the high velocity revolution of the single roll, carries out high speed heating of the metal, fuses it, and carries out high speed injection to a cooling medium using back pressure, such as Ar gas.
[0016]Next, metal is carried out mixing 38 as the child particles 37 as a binder. Copper (Cu) which is metal whose melting point is higher than the crystallization temperature of the above-

mentioned amorphous **** rapid solidification system magnetic powder is used for the metal of this child particle 37. In addition to this Cu, Cu system alloy (Cu-Zn, Cu-Zn-Ag), titanium (Ti), aluminum (aluminum), silver (Ag), gold (Au), etc. of a nonmagnetic field can be used.
[0017]Nd-Fe-B used for the mother particle 31 is magnetic powder with a size of about 200 micrometers.
Cu used for child particles is a metal powder with a size of about 15 micrometers.
The rate of the child particles 37 was carried out mixing 38 at a rate of 3% by weight % to the mother particle 31.
[0018]Thus, it is mixable in the state of a capsule so that the child particles 37 may wrap the mother particle 31 in setting the diameter of the child particles 37 as 1/20 from 1/10 to the diameter of the mother particle 31. Using an adhesion operation of plating, weld slag, vacuum evaporation, collision adhesion, etc., this capsule state wraps the circumference of the mother particle 31 in the child particles 37 as shown in drawing 2. These aim at carrying out the coat of the surface to a shaped object, or intercepting a shaped object from open air atmosphere etc. This capsule state can be generated with the attraction of high BURIZESHON and the electrification potential by the mother particle 31 and the child particles 37 looked at by electrostatic coating. With shot peening using a SHOKU wave or a fluid medium, etc., the mother particle 31 and the child particles 37 can be made to be able to collide, striking energy can be changed, and this can be generated with contacting parts. Using an electron discharge method, electrical energy can be given between the mother particle 31 and the child particles 37, and it can patch with Joule heat, and can obtain in total.
[0019]By the energization solidifying method, the grain boundary side is changed into an activity state by energization, carry out the powder of the above-mentioned capsule state solidification 39, and let this be the product 40. The conditions of this energization solidifying method are set as the temperature of 550 **, pressure 5 t/cm^2, and current density 1 kA/cm^2, and atmosphere is set as the conditions in the atmosphere.
[0020]Next, the operation in the above-mentioned example is described.
[0021]The magnetic properties of the metal magnet 40 manufactured as mentioned above are shown in Table 1.
[0022]
[Table 1]

Br [G]	iHc [Oe]	BHmax [MGOe]
7603	8758	11.05

[0023]The magnetic properties of the plastic magnet which uses a plastic as a binder are shown in Table 2 as comparison.
[0024]
[Table 2]

Br [G]	iHc [Oe]	BHmax [MGOe]
6650	8150	8.30

[0025]The magnetic properties of the Nd-Fe-B magnetic powder used for the manufacturing method of the metal magnet concerning this invention are shown in Table 3.
[0026]
[Table 3]

Br [G]	iHc [Oe]	BHmax [MGOe]
8070	9080	11.94

[0027]That is, the metal magnet applied to this invention from Table 1 thru/or 3 to the conventional plastic magnet showing 70% of magnetic properties of magnetic powder shows 93% of magnetic properties of magnetic powder, and it turns out that the magnetic properties of magnetic powder can fully be pulled out.
[0028]Table 4 shows comparison of the compressive strength test of the metal magnet concerning this invention, the conventional plastic magnet, and the conventional metal magnet (Zn-aluminum-Cu system alloy).
[0029]
[Table 4]

本発明に係る金属磁石	従来のプラスチック磁石	従来の金属磁石
1500 [kg/cm²]	500 [kg/cm²]	600 [kg/cm²]

[0030]From the comparison result of Table 4, it was checked in the conventional metal magnet that the compressive strength is governed by Zn rich phase in a magnetic particle side. In the metal magnet concerning this invention, since the melting point of the child particles 37 was higher enough than solidification temperature, it was checked that separation of a phase is not seen. Therefore, it is considered that compressive strength higher than the conventional metal magnet can be obtained. However, when [near the closest packing] it solidifies by the metal child particles 37 of vol 40%, also in the metal magnet concerning this invention, the melt phase of a particle element is seen in part, and compressive strength falls.
[0031]Doing the electrical resistance test about the metal magnet concerning this invention, the result was 1.42×10^{-6} [omegacm].
[0032]And the thermal expansion test was done about the metal magnet concerning this invention, and the result was 4.3×10^{-6} [l/**].
[0033]Next, the Vickers hardness test was done about the metal magnet concerning this invention, and the result was 660-750 [Hv].
[0034]Drawing 3 is a graph which shows magnetic properties when a Nd-Fe-B magnetic material is used as a mother particle, it uses Cu as child particles and the rate of child particles over a mother particle is set up from 1% to 40% by weight %, and the result of compressive strength.
[0035]Magnetic properties were comparatively stable, and when the percentage of Cu was about 15% in weight %, as for compressive strength, the peak was seen as illustrated.
[0036]Drawing 4 is a graph which shows magnetic properties when a solidification pressure is set up from 1 [t/cm^2] to 7 [t/cm^2], and the result of compressive strength on solidification conditions.
[0037]Magnetic properties increased along with the rise of a solidification pressure, and compressive strength was stabilized from the solidification pressure 3 [t/cm^2] grade as illustrated.
[0038]And drawing 5 is a graph which shows magnetic properties when solidification temperature is set up from 550 [**] to 800 [**], and the result of compressive strength on solidification conditions.
[0039]Magnetic properties are excellent in 600 [**] to 750 [**] in solidification temperature, and compressive strength increased gradually along with the rise of solidification temperature as illustrated.

[0040]
[Effect of the Invention]As stated above, according to the manufacturing method of the metal magnet concerning this invention, the rapid solidification system magnetic powder containing AMORUFASU can be solidified using the metal whose melting point is higher than the crystallization temperature, and the outstanding effect that sufficient magnetic property and usable intensity can be obtained is demonstrated.

[Translation done.]

TECHNICAL FIELD

[Industrial Application]This invention relates to the manufacturing method of the metal magnet which uses the metal in which the boiling point is higher than the crystallization temperature of this rapid solidification system magnetic powder as child particles by making into a mother particle rapid solidification system magnetic powder which is applied to the manufacturing method of a metal magnet, especially contains AMORUFASU.

[Translation done.]

PRIOR ART

[Description of the Prior Art]Generally, the plastic magnet is accomplished by carrying out the joint solidification of the rapid solidification system magnetic powder which contains AMORUFASU using a plastic as a binder.
[0003]Specifically, the manufacturing method of the plastic magnet is accomplished, as shown in drawing 6. The alloy 2 of neodium (Nd), iron (Fe), and boron (B) is first mixed in the NEOKEMU Nd metal 1 as illustrated. Next, what carried out this mixture jet cast 3 is carried out grinding 4, and disintegration is carried out. And after performing predetermined heat treatment 5 to this, the epoxy resin 6 is mixed as a binder and it takes press 7. Then, this press-forming article is carried out curing treatment 8, and it is considered as the product 9.
[0004]However, if it is in the above-mentioned plastic magnet, the plastic is used as a binder which solidifies magnetic powder. Since it must mix not less than 15% by volume not less than 3% with weight to magnetic powder, this plastic cannot pull out performance of the above-mentioned magnetic powder 100%. To a temperature change, a plastic magnet is weak, and changes at 200 ** at the elevated-temperature side, and a crack arises at -20 ** at the low temperature side. Therefore, a plastic magnet cannot be used in a broad temperature requirement. In a mechanical strength, although there is also correlation with temperature, it does not have intensity [in addition to a specific temperature field] other than -10 ** - 150 **, for example. And it is difficult for the plastic used as a binder to recycle what it went variously and was once manufactured as a plastic magnet.
[0005]Then, the metal magnet is improved. That for which this metal magnet used the cast magnet or the sintered magnet is used abundantly. The above-mentioned cast magnet is manufactured in the casting process which is made to carry out thermofusion of the metallic component by high frequency, and is cast to a mold, and the above-mentioned sintered magnet is manufactured with the sintering process which used tin series metal as the binder.
[0006]Specifically, the manufacturing method of the above-mentioned sintered magnet is accomplished, as shown in drawing 7. These are first carried out combination 11 by a predetermined daily dose by making Nd, Fe, B, etc. into the raw material 10 as illustrated. Next, this feed ingredient is carried out dissolution 12, and it is casting 13 ** in a mold. After releasing from mold and carrying out a casting coarse-grinding 14 after solidification, it takes pulverizing 15 with a ball mill etc. And this powder is carried out shaping 16 in a magnetic field, and predetermined heat treatment 18 is performed after the sintering 17. Then, this is carried out polishing work 19 and it is considered as the product 20.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention]As stated above, according to the manufacturing method of the metal magnet concerning this invention, the rapid solidification system magnetic powder containing AMORUFASU can be solidified using the metal whose melting point is higher than the crystallization temperature, and the outstanding effect that sufficient magnetic property and usable intensity can be obtained is demonstrated.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention]by the way -- if it is in the conventional metal magnet -- a casting process and a sintering process (a binder is included) -- it needs both to be heated more than the melting point. Therefore, the temperature transformation of crystallization etc. was located in the third grade of the melting point, and the rapid solidification system magnetic powder containing AMORUFASU had the problem that what has the desired characteristic could not be manufactured, in these casting processes and a sintering process. Although the sintering process was manufactured in consideration of deterioration temperature in part, in order to have to choose the binder metal of a low melting point, there was a problem that sufficient usable intensity could not be obtained.
[0008]The purpose of this invention is in view of an aforementioned problem to provide the manufacturing method of the metal magnet which can solidify the rapid solidification system magnetic powder containing AMORUFASU using the metal whose melting point is higher than the crystallization temperature, and can obtain sufficient magnetic property and usable intensity.

[Translation done.]

MEANS

[Means for Solving the Problem]According to the manufacturing method of a metal magnet concerning this invention, rapid solidification system magnetic powder containing AMORUFASU is made into a mother particle, and metal whose melting point is higher than crystallization temperature of this rapid solidification system magnetic powder is made into child particles, it mixes, and the above-mentioned purpose is attained by changing that grain boundary side into an activity state by energization, and having made it solidify.

[Translation done.]

OPERATION

[Function]According to the above-mentioned composition, the rapid solidification system magnetic powder containing AMORUFASU was used as a mother particle, and metal was used as child particles, and these were mixed. For example, it is mixable in the state of a capsule so that child particles may wrap a mother particle in setting the diameter of child particles as 1/20 from 1/10 to the diameter of a mother particle.
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[0012]Therefore, since the metal whose melting point is higher than the crystallization temperature of the rapid solidification system magnetic powder containing AMORUFASU can be used, sufficient magnetic property and usable intensity can be obtained.

[Translation done.]

EXAMPLE

[Example]Hereafter, suitable 1 example of the manufacturing method of the metal magnet concerning this invention is explained in full detail based on an accompanying drawing.
[0014]Drawing 1 is an explanatory view showing the manufacturing method of the metal magnet of this example. the rapid solidification system Nd-Fe-B magnetic powder which used the single chill roll method for the amorphous magnetic material as the mother particle 31, and was manufactured was boiled and used as illustrated. Amorphous magnetic powder is also included in this rapid solidification system magnetic powder. This amorphous ****** is the meaning in which a rapid solidification system alloy contains what is amorphous with material composition since micro crystallite is metastable with quenching about that sequence regularity.
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[0019]By the energization solidifying method, the grain boundary side is changed into an activity state by energization, carry out the powder of the above-mentioned capsule state solidification

39, and let this be the product 40. The conditions of this energization solidifying method are set as the temperature of 550 **, pressure 5 t/cm^2, and current density 1 kA/cm^2, and atmosphere is set as the conditions in the atmosphere.
[0020]Next, the operation in the above-mentioned example is described.
[0021]The magnetic properties of the metal magnet 40 manufactured as mentioned above are shown in Table 1.
[0022]
[Table 1]

Br [G]	iHc [Oe]	BHmax [MGOe]
7603	8758	11.05

[0023]The magnetic properties of the plastic magnet which uses a plastic as a binder are shown in Table 2 as comparison.
[0024]
[Table 2]

Br [G]	iHc [Oe]	BHmax [MGOe]
6650	8150	8.30

[0025]The magnetic properties of the Nd-Fe-B magnetic powder used for the manufacturing method of the metal magnet concerning this invention are shown in Table 3.
[0026]
[Table 3]

Br [G]	iHc [Oe]	BHmax [MGOe]
8070	9080	11.94

[0027]That is, the metal magnet applied to this invention from Table 1 thru/or 3 to the conventional plastic magnet showing 70% of magnetic properties of magnetic powder shows 93% of magnetic properties of magnetic powder, and it turns out that the magnetic properties of magnetic powder can fully be pulled out.
[0028]Table 4 shows comparison of the compressive strength test of the metal magnet concerning this invention, the conventional plastic magnet, and the conventional metal magnet (Zn-aluminum-Cu system alloy).
[0029]
[Table 4]

本発明に係る金属磁石	従来のプラスチック磁石	従来の金属磁石
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higher enough than solidification temperature, it was checked that separation of a phase is not seen. Therefore, it is considered that compressive strength higher than the conventional metal magnet can be obtained. However, when [near the closest packing] it solidifies by the metal child particles 37 of vol 40%, also in the metal magnet concerning this invention, the melt phase of a particle element is seen in part, and compressive strength falls.
[0031]Doing the electrical resistance test about the metal magnet concerning this invention, the result was 1.42×10^{-6} [omegacm].
[0032]And the thermal expansion test was done about the metal magnet concerning this invention, and the result was 4.3×10^{-6} [l/**].
[0033]Next, the Vickers hardness test was done about the metal magnet concerning this invention, and the result was 660-750 [Hv].
[0034]Drawing 3 is a graph which shows magnetic properties when a Nd-Fe-B magnetic material is used as a mother particle, it uses Cu as child particles and the rate of child particles over a mother particle is set up from 1% to 40% by weight %, and the result of compressive strength.
[0035]Magnetic properties were comparatively stable, and when the percentage of Cu was about 15% in weight %, as for compressive strength, the peak was seen as illustrated.
[0036]Drawing 4 is a graph which shows magnetic properties when a solidification pressure is set up from 1 [t/cm^2] to 7 [t/cm^2], and the result of compressive strength on solidification conditions.
[0037]Magnetic properties increased along with the rise of a solidification pressure, and compressive strength was stabilized from the solidification pressure 3 [t/cm^2] grade as illustrated.
[0038]And drawing 5 is a graph which shows magnetic properties when solidification temperature is set up from 550 [**] to 800 [**], and the result of compressive strength on solidification conditions.
[0039]Magnetic properties are excellent in 600 [**] to 750 [**] in solidification temperature, and compressive strength increased gradually along with the rise of solidification temperature as illustrated.

[Translation done.]

DESCRIPTION OF DRAWINGS

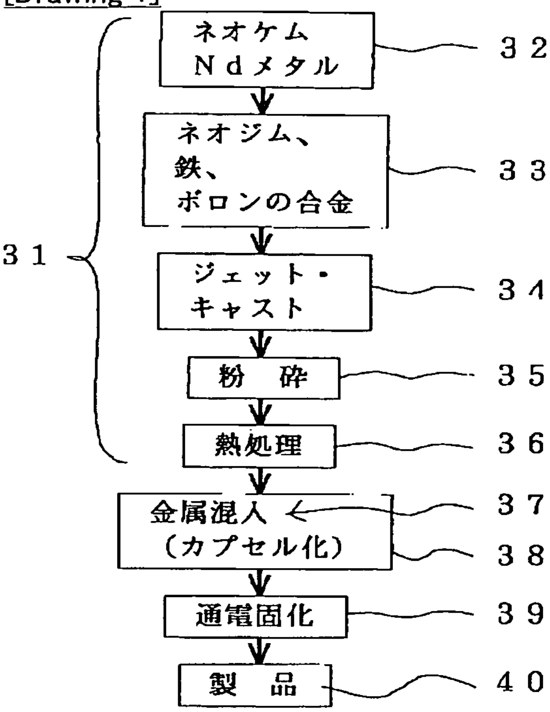
[Brief Description of the Drawings]
[Drawing 1]It is an explanatory view showing one example of the manufacturing method of the metal magnet concerning this invention.
[Drawing 2]It is a schematic diagram showing the capsule state of the mother particle and child particles in one example of the manufacturing method of the metal magnet concerning this invention.
[Drawing 3]The graph which shows magnetic properties when a Nd-Fe-B magnetic material is used as a mother particle, Cu is used as child particles and the rate of child particles over a mother particle is set up from 1% to 40% by weight %, and the result of compressive strength.
[Drawing 4]The graph which shows magnetic properties when a solidification pressure is set up from 1 [t/cm^2] to 7 [t/cm^2], and the result of compressive strength on solidification conditions.
[Drawing 5]The graph which shows magnetic properties when solidification temperature is set up from 550 [**] to 800 [**], and the result of compressive strength on solidification conditions.
[Drawing 6]It is an explanatory view showing an example of the manufacturing method of the conventional plastic magnet.
[Drawing 7]It is an explanatory view showing an example of the manufacturing method of the conventional metal magnet.
[Description of Notations]
31 Mother particle
37 Child particles
39 Energization solidification

[Translation done.]

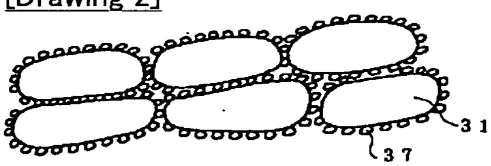
* NOTICES *

DRAWINGS

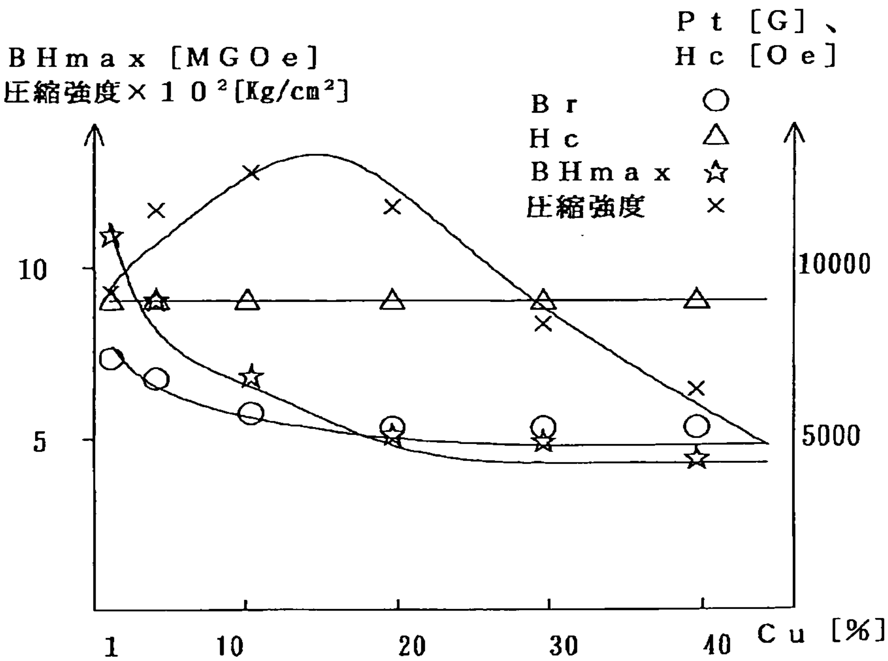
[Drawing 1]



[Drawing 2]

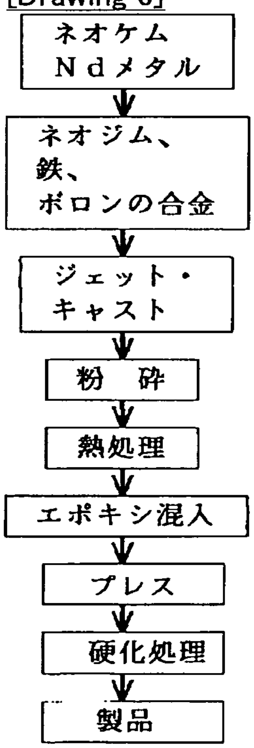


[Drawing 3]

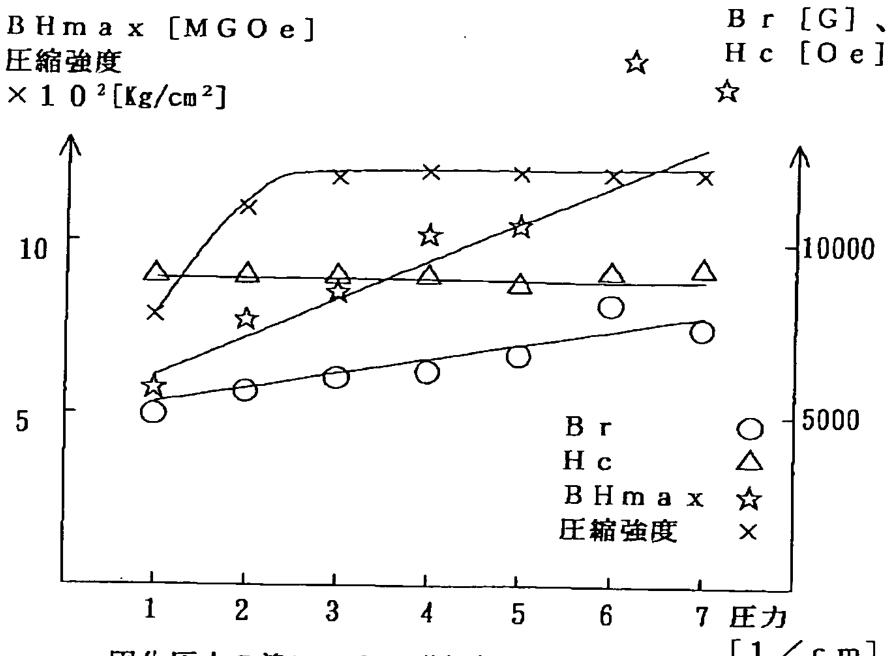


Cu添加量による磁気特性と圧縮強度

[Drawing 6]

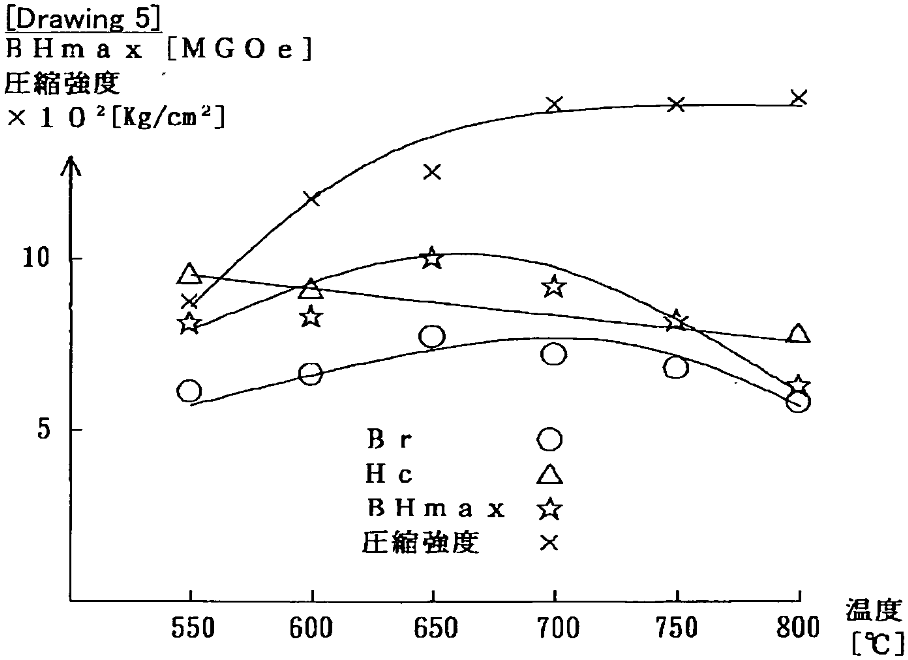


[Drawing 4]



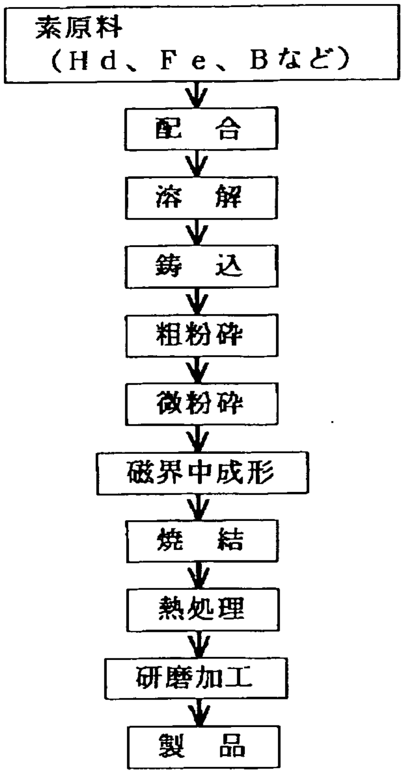
固化圧力の違いによる磁気特性と圧縮強度

[Drawing 5]



固化温度の違いによる磁気特性と圧縮強度

[Drawing 7]



[Translation done.]

3/3

(19)日本国特許庁（ＪＰ）　(12) 公 開 特 許 公 報（Ａ）　(11)特許出願公開番号

特開平5－175029

(43)公開日　平成５年(1993)７月13日

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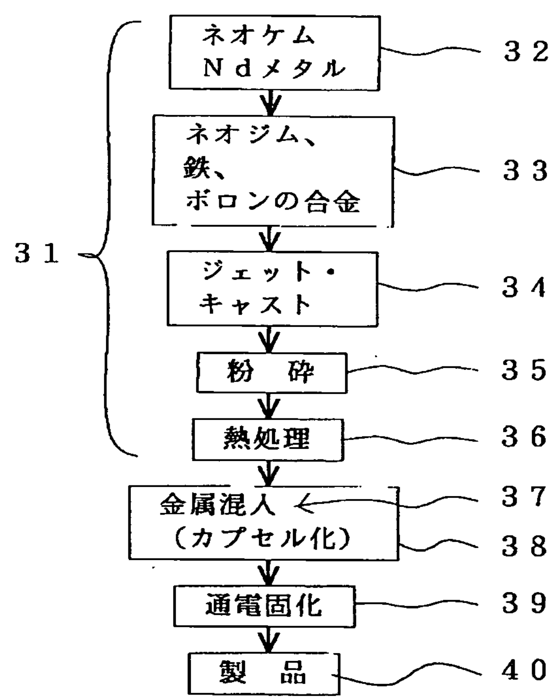
(54)【発明の名称】　金属磁石の製造方法

(57)【要約】

【目的】　アモルファスを含む急冷凝固系磁性粉をその結晶化温度より融点の高い金属を用いて固化することができ、十分な磁性特性及び使用可能強度を得ることができる金属磁石の製造方法を提供する。

【構成】　アモルファスを含む急冷凝固系磁性粉を母粒子３１とし、この急冷凝固系磁性粉の結晶化温度より融点の高い金属を子粒子３１として混合し、その粒界面を通電により活性な状態にして固化３９するようにしたものである。



【特許請求の範囲】

【請求項１】　アモルファスを含む急冷凝固系磁性粉を母粒子とし、該急冷凝固系磁性粉の結晶化温度より融点の高い金属を子粒子とし混合し、その粒界面を通電により活性な状態にして固化するようにしたことを特徴とする金属磁石の製造方法。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は金属磁石の製造方法に係り、特にアモルファスを含む急冷凝固系磁性粉を母粒子として、該急冷凝固系磁性粉の結晶化温度より沸点の高い金属を子粒子として使用した金属磁石の製造方法に関する。

【０００２】

【従来の技術】一般に、プラスチック磁石は、バインダとしてプラスチックを用いてアモルファスを含む急冷凝固系磁性粉を結合固化させることにより成されている。

【０００３】具体的には、プラスチック磁石の製造方法は、図６に示すように成されている。図示されているように、まず、ネオケムＮｄメタル１に、ネオジウム（Ｎｄ），鉄（Ｆｅ）及びボロン（Ｂ）の合金２を混合する。次に、この混合物をジェットキャスト３したものを粉砕４して粉末化する。そして、これに所定の熱処理５を施した後、バインダとしてエポキシ樹脂６を混入してプレス７する。その後、このプレス成形品を硬化処理８して製品９としている。

【０００４】しかし、上記プラスチック磁石にあっては、磁性粉を固化するバインダとしてプラスチックを用いている。このプラスチックは、磁性粉に対し重量で３%以上、体積で１５%以上混入しなければならないため、上記磁性粉の性能を１００%引き出すことはできない。また、プラスチック磁石は温度変化に対して弱く、高温側では２００℃で変形し、低温側では－２０℃で割れが生じる。従って、プラスチック磁石を幅広い温度範囲で使用することはできない。さらに、機械的強度においては、温度との相関関係もあるが、特定温度領域以外においては、例えば、－１０℃～１５０℃以外においては強度を有しない。そして、バインダとして用いるプラスチックが多種多様にわたり、一旦プラスチック磁石として製造したものをリサイクルすることは困難である。

【０００５】そこで、金属磁石が見直されている。この金属磁石は、鋳造磁石或いは焼結磁石を用いたものが多用されている。上記鋳造磁石は金属成分を高周波で熱溶融させて鋳型に鋳込む鋳造法にて製造され、又、上記焼結磁石はスズ系金属をバインダとした焼結法にて製造されている。

【０００６】具体的には、上記焼結磁石の製造方法は、図７に示すように成されている。図示されているように、まず、Ｎｄ，Ｆｅ及びＢ等を素原料１０として、これらを所定の分量で配合１１する。次に、この配合原料を溶解１２して鋳型内に鋳込１３む。固化後、離型して鋳物を粗粉砕１４した後、ボールミル等で微粉砕１５する。そして、この粉末を磁界中で成形１６して焼結１７後、所定の熱処理１８を行う。その後、これを研磨加工１９して、製品２０としている。

【０００７】

【発明が解決しようとする課題】ところで、従来の金属磁石にあっては、鋳造法・焼結法（バインダを含む）共に融点以上の加熱が必要である。従って、アモルファスを含む急冷凝固系磁性粉は結晶化等の温度変態が融点の三分の一程度に位置しており、これら鋳造法・焼結法では、所望の特性を有するものを製造することはできないという問題があった。一部に変質温度を考慮して製造されるのが焼結法であるが、低融点のバインダ金属を選択しなければならないため、十分な使用可能強度を得ることができないという問題があった。

【０００８】上記課題に鑑み、本発明の目的は、アモルファスを含む急冷凝固系磁性粉をその結晶化温度より融点の高い金属を用いて固化することができ、十分な磁性特性及び使用可能強度を得ることができる、金属磁石の製造方法を提供するにある。

【０００９】

【課題を解決するための手段】上記目的は、本発明に係る金属磁石の製造方法によれば、アモルファスを含む急冷凝固系磁性粉を母粒子とし、この急冷凝固系磁性粉の結晶化温度より融点の高い金属を子粒子とし混合し、その粒界面を通電により活性な状態にして固化するようにしたことにより達成される。

【００１０】

【作用】上記構成によれば、アモルファスを含む急冷凝固系磁性粉を母粒子として使用し、又、金属を子粒子として使用して、これらを混合した。例えば、母粒子の直径に対して子粒子の直径を十分の一から二十分の一に設定することで、子粒子が母粒子を包み込むようにカプセル状態で混合することができる。

【００１１】また、上記母粒子としてのアモルファスを含む急冷凝固系磁性粉を上記子粒子としての金属を用いて固化するに際して、その粒界面を通電により活性な状態にして固化する通電固化法を用いることにより、アモルファスを含む急冷凝固系磁性粉をその結晶化温度より融点の高い金属を用いて固化することができる。

【００１２】従って、アモルファスを含む急冷凝固系磁性粉の結晶化温度より融点の高い金属を用いることができるので、十分な磁性特性及び使用可能強度を得ることができるものである。

【００１３】

【実施例】以下、本発明に係る金属磁石の製造方法の好適一実施例を添付図面に基づいて詳述する。

【００１４】図１は本実施例の金属磁石の製造方法を示す説明図である。図示されているように、母粒子３１と

して非晶質磁性材料に単ロール急冷法を用いて製造された急冷凝固系Ｎｄ－Ｆｅ－Ｂ磁性粉をに用いた。この急冷凝固系磁性粉には、アモルファス磁性粉も含むものである。このアモルファスも含むとは、急冷凝固系合金が微結晶がその列的規則性を急冷によって準安定になっているので、材料組成によって非晶質になっているものも含む趣旨である。

【００１５】具体的には、上記母粒子３１は、まず、ネオケムＮｄメタル３２に、ネオジウム（Ｎｄ），鉄（Ｆｅ）及びボロン（Ｂ）の合金３３を混合し、この混合物をジェットキャスト３４したものを粉砕３５して粉末化した後、これに所定の熱処理３６を施して製造される。また、この単ロール急冷法によるジェットキャストとは、単ロールを高速回転して金属を高速加熱して溶融し、冷却媒体にＡｒガス等の背圧を利用して高速噴射するものである。

【００１６】次に、バインダとして子粒子３７として金属を混入３８する。この子粒子３７の金属には、上記アモルファス含む急冷凝固系磁性粉の結晶化温度より融点の高い金属である銅（Ｃｕ）を使用する。このＣｕ以外には、非磁性領域のＣｕ系合金（Ｃｕ－Ｚｎ，Ｃｕ－Ｚｎ－Ａｇ），チタン（Ｔｉ），アルミニウム（Ａｌ），銀（Ａｇ）及び金（Ａｕ）等を使用することができる。

【００１７】尚、母粒子３１に使用したＮｄ－Ｆｅ－Ｂは、約２００μm程度の大きさの磁性粉であり、又、子粒子に使用したＣｕは、約１５μmの大きさの金属粉である。また、母粒子３１に対して子粒子３７の割合は、重量%で３%の割合で混入３８した。

【００１８】このように、母粒子３１の直径に対して子粒子３７の直径を十分の一から二十分の一に設定することで、子粒子３７が母粒子３１を包み込むようにカプセル状態で混合することができる。このカプセル状態とは、メッキ，スパッタ，蒸着及び衝突付着などの付着作用を利用して、図２に示されているように母粒子３１の周囲を子粒子３７で包むものである。これらは、形状物に対して表面をコートしたり、形状物を外気雰囲気から遮断することなどを目的としている。このカプセル状態は、ハイブリゼーションや、静電塗装に見られる、母粒子３１と子粒子３７とによる帯電電位の引力により発生させることができる。また、ショクウェーブや流体媒体を利用するショットピーニング等により、母粒子３１と子粒子３７とを衝突させて衝撃エネルギを変えて、接触部分をもってこれを生成することができる。さらに、放電加工を利用して、母粒子３１と子粒子３７との間に電気的エネルギを与えてジュール熱により接合せしめて得ることができる。

【００１９】上記カプセル状態の粉末を通電固化法により、その粒界面を通電により活性な状態にして固化３９し、これを製品４０とする。この通電固化法の条件は、温度５５０℃、圧力５ｔ／ｃｍ^2、電流密度１ｋＡ／ｃｍ^2、雰囲気は大気中の条件に設定している。

【００２０】次に、上記実施例における作用を述べる。

【００２１】上述のように製造された金属磁石４０の磁気特性を表１に示す。

【００２２】

【表１】

Ｂｒ［Ｇ］	ｉＨｃ［Ｏｅ］	ＢＨｍａｘ［ＭＧＯｅ］
７６０３	８７５８	１１．０５

【００２３】また、比較として、バインダとしてプラスチックを使用したプラスチック磁石の磁気特性を表２に示す。

【００２４】

【表２】

Ｂｒ［Ｇ］	ｉＨｃ［Ｏｅ］	ＢＨｍａｘ［ＭＧＯｅ］
６６５０	８１５０	８．３０

【００２５】さらに、本発明に係る金属磁石の製造方法に用いたＮｄ－Ｆｅ－Ｂ磁性粉の磁気特性を表３に示す。

【００２６】

【表３】

Ｂｒ［Ｇ］	ｉＨｃ［Ｏｅ］	ＢＨｍａｘ［ＭＧＯｅ］
8070	9080	11．94

【００２７】すなわち、表１乃至表３から、従来のプラスチック磁石が磁性粉の７０％の磁気特性を示すのに対し、本発明に係る金属磁石は磁性粉の９３％の磁気特性を示しており、磁性粉の磁気特性を十分に引き出すことができることが判る。

【００２８】また、表４は、本発明に係る金属磁石，従来のプラスチック磁石及び従来の金属磁石（Ｚｎ－Ａｌ－Ｃｕ系合金）の圧縮強度テストの比較を示す。

【００２９】

【表４】

本発明に係る金属磁石	従来のプラスチック磁石	従来の金属磁石
1500［ｋｇ／ｃｍ^2］	500 ［ｋｇ／ｃｍ^2］	600 ［ｋｇ／ｃｍ^2］

【００３０】表４の比較結果から、従来の金属磁石においては、その圧縮強度が、磁性粒子面にあるＺｎリッチ相によって支配されていることが確認された。また、本発明に係る金属磁石においては、子粒子３７の融点が固化温度より十分に高いため、相の分離は見られないことが確認された。そのために、従来の金属磁石より高い圧縮強度を得ることができると考察される。しかし、最密充填に近い４０％ｖｏｌの金属子粒子３７で固化した場合、本発明に係る金属磁石においても、一部に粒子元素の溶融相が見られ、圧縮強度が低下する。

【００３１】さらに、本発明に係る金属磁石について電気抵抗テストを行い、その結果は、１．４２×１０$^{-6}$［Ωｃｍ］であった。

【００３２】そして、本発明に係る金属磁石について熱膨張テストを行い、その結果は、４．３×１０$^{-6}$［ｌ／℃］であった。

【００３３】次に、本発明に係る金属磁石についてビッカース硬度テストを行い、その結果は、６６０～７５０［Ｈｖ］であった。

【００３４】また、図３は、母粒子としてＮｄ－Ｆｅ－Ｂ磁性材料を、子粒子としてＣｕを使用し、母粒子に対する子粒子の割合を重量％で１％から４０％まで設定したときの磁気特性及び圧縮強度の結果を示すグラフである。

【００３５】図示されているように、磁気特性は比較的安定しており、圧縮強度はＣｕの割合が重量％で１５％近傍であるときにピークが見られた。

【００３６】さらに、図４は、固化条件において、固化圧力を１［ｔ／ｃｍ^2］から７［ｔ／ｃｍ^2］まで設定したときの磁気特性及び圧縮強度の結果を示すグラフである。

【００３７】図示されているように、磁気特性は固化圧力の上昇につれて増加し、圧縮強度は固化圧力３［ｔ／ｃｍ^2］程度から安定した。

【００３８】そして、図５は、固化条件において、固化温度を５５０［℃］から８００［℃］まで設定したときの磁気特性及び圧縮強度の結果を示すグラフである。

【００３９】図示されているように、磁気特性は固化温度を６００［℃］から７５０［℃］の範囲で優れており、圧縮強度は固化温度の上昇につれて徐々に増加した。

【００４０】

【発明の効果】以上述べたように、本発明に係る金属磁石の製造方法によれば、アモルファスを含む急冷凝固系磁性粉をその結晶化温度より融点の高い金属を用いて固化することができ、十分な磁性特性及び使用可能強度を得ることができる、という優れた効果を発揮する。

【図面の簡単な説明】

【図１】本発明に係る金属磁石の製造方法の一実施例を示す説明図である。

【図２】本発明に係る金属磁石の製造方法の一実施例における母粒子と子粒子とのカプセル状態を示す概略図である。

【図３】母粒子としてＮｄ－Ｆｅ－Ｂ磁性材料を、子粒子としてＣｕを使用し、母粒子に対する子粒子の割合を重量％で１％から４０％まで設定したときの磁気特性及び圧縮強度の結果を示すグラフ。

【図４】固化条件において、固化圧力を１［ｔ／ｃｍ^2］から７［ｔ／ｃｍ^2］まで設定したときの磁気特性及び圧縮強度の結果を示すグラフ。

【図５】固化条件において、固化温度を５５０［℃］から８００［℃］まで設定したときの磁気特性及び圧縮強度の結果を示すグラフ。

【図６】従来のプラスチック磁石の製造方法の一例を示す説明図である。

【図７】従来の金属磁石の製造方法の一例を示す説明図

である。

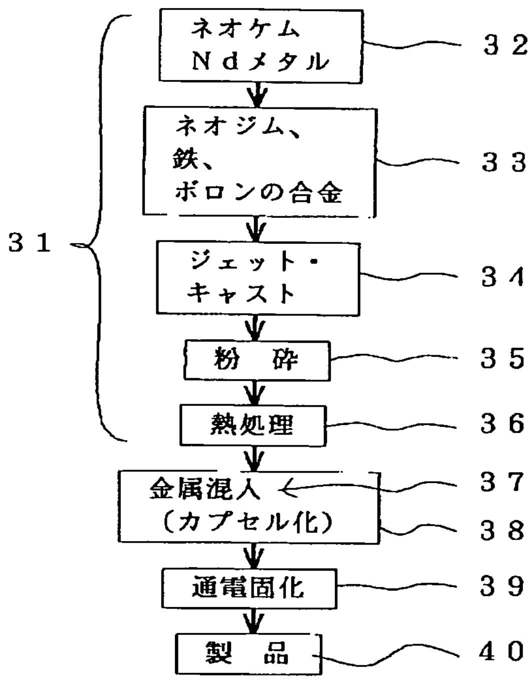
【符号の説明】

３１　母粒子

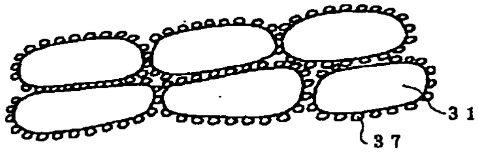
３７　子粒子

３９　通電固化

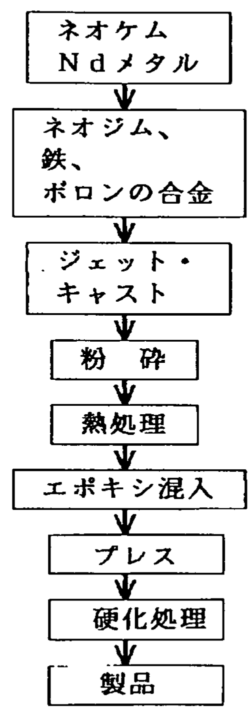
【図１】



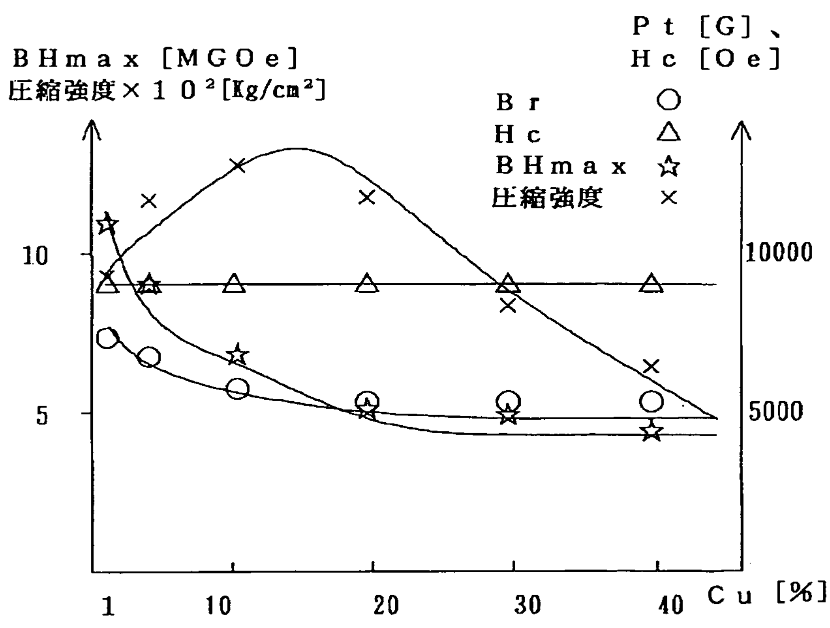
【図２】



【図６】

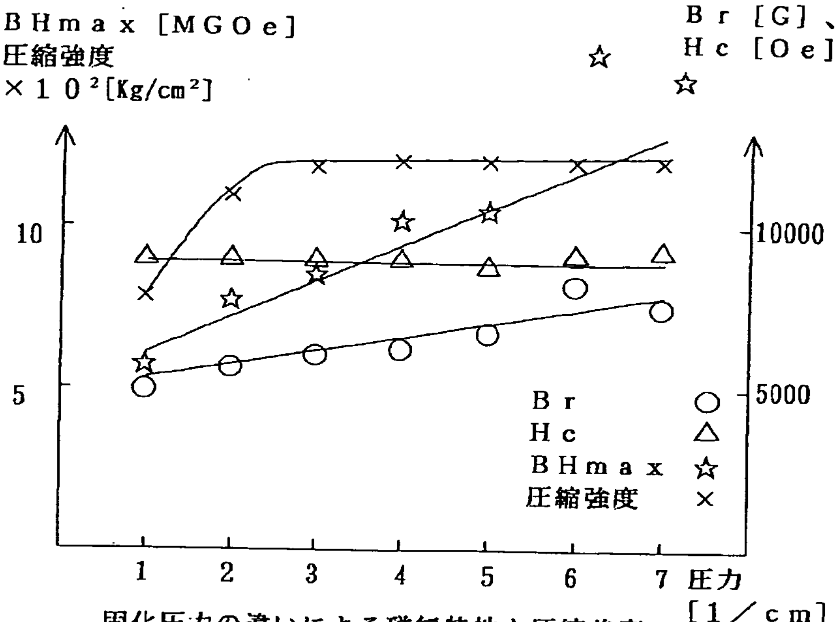


【図３】



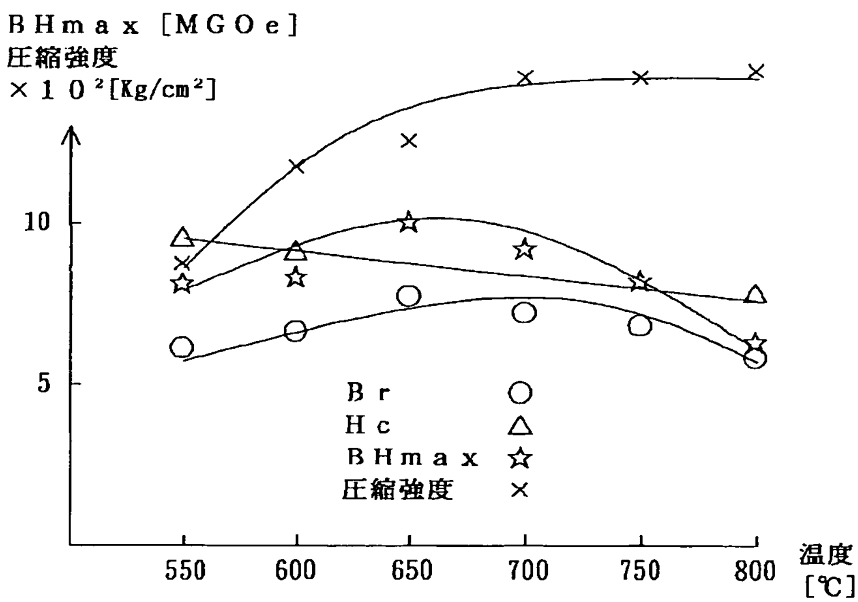
Ｃｕ添加量による磁気特性と圧縮強度

【図4】



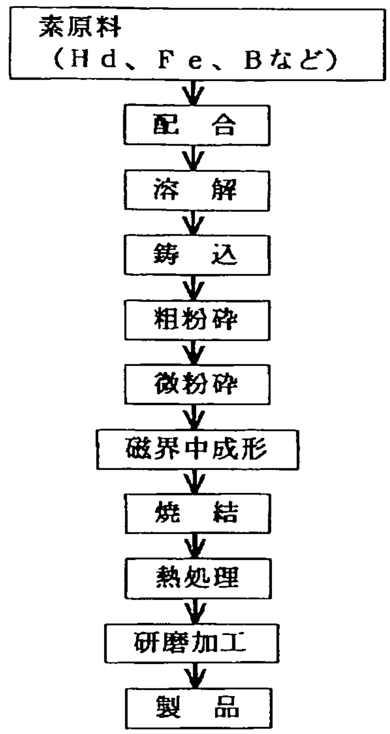
固化圧力の違いによる磁気特性と圧縮強度

【図5】



固化温度の違いによる磁気特性と圧縮強度

【図7】



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